Ticketing artefacts and designing fare collection systems

TRANSPORT FINDINGS

Ticketing artefacts and designing fare collection systems

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Findings

The transport ticketing board is a physical, interactive learning aid that presents a dynamic and interactive categorisation framework of ticketing types to help educate students and transport professionals about the choices faced when designing passenger transport ticketing, and hence inform the next generation of systems. The learning aid comprises tickets collected from around the world displayed on an electronic board. It was developed to encourage students and visiting public transport professionals to discuss issues around designing optimal transport ticketing systems. It highlights the complexity and consequent diversity of systems globally which indicates the importance of context in making choices.

1. Questions

Ticketing systems, also known as Revenue or Fare Collection Systems are mechanisms by which public transport users pay for the right to travel (Harvey 2015). Transport tickets act as proof of entitlement to travel for the user and those that control the transport system (Glover 1999). Well-designed ticketing systems are fundamental to managing public transport operations, but what does the 'optimal' ticketing system look like, and why is there such a diverse range? The board offers new insights about the range of choices available to transport practitioners and the implications of those choices on achieving often conflicting user and operator outcomes.

We ask:w

How do we build something to encourage students and practitioners to talk about issues around the choices and trade-offs facing designers of passenger transport ticketing systems face; the factors influencing these choices; and how ticketing systems look in the future?

2. Methods

We analysed 'artefacts' (i.e. appropriate physical manifestations of the process under investigation, in this case public transport tickets from around the world) formed the primary data. We adopted the 'found object' practice to reinterpret values, metaphors or the status-quo through the outputs from objects (Chilvers and Glaves-Smith 2015; Harrison and Wood 2002). We used the approach previously to help students explore different methods for managing car use (see Enoch and Warren 2020).

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This analysis comprised seven steps.

Step 1: Transport tickets (>100) from many modes and countries were collected to determine a broad range of ticketing system characteristics.

Step 2: We developed a categorisation framework based on the collection analysis and on literature (e.g. Vuchic 2005; Fleishman et al. 1996). Ticketing systems were characterised against twelve attributes – nine charging-related and three media-related (see Table 1) – and each attribute provided a number of options for the designers of ticket systems to make. Overall, 55 attributes result in 6.08 million possible outcomes!

Step 3: The framework was graphically arranged with each attribute represented like a metro line on a network map, and a series of 'stations' representing discrete ticketing system design options that could be chosen (see Figure 1).

Step 4: We selected 16 tickets to efficiently cover the design options, whilst covering many modes and countries of origin and these were categorised against each of the twelve attributes and 'plotted' for each ticket in a spreadsheet (Supplementary S1).

Step 5: The performance of each design option for each attribute was assessed against six ticketing system policy objectives – three from a user perspective, and three from an operator perspective in a spreadsheet (see Figure 2 for examples and Supplementary S2).

Step 6: The results were displayed on a purpose-built electronic 'ticketing board' which is 1.2 metres wide and 0.9 metres high and comprises a printed circuit board controlled by the two spreadsheet-based algorithms. Actioned by 34 push buttons, 89 LEDs, and electric wire, the board has two key functions. The first allows users to categorise each ticket (arranged around the network map). On pressing the ticket, one LED per attribute line lights up to illustrate the specific characteristics of the ticket being pressed. The second allows users to explore how each design option for a selected attribute performs against each policy objective (a dim light means it performs 'poorly', a medium light 'average' and a bright light 'strongly'). From this, the user can visually compare how the design options for the distance discrimination attribute (i.e. flat fare, zonal fare, stage-based fare and mileage-based fare) perform against the simplicity and revenue maximisation policy objectives for example. See Figure 3 to see the board in use.

Step 7: Implications for policy makers can be determined. As of 31 July 2021, informal discussions have resulted from approximately 20 academic and transport operator colleagues and 150 undergraduate transport students.

Table 1. Twelve attributes in two domains linked to ticketing systems.

Fare structuring domain: 9 attributes		
Attribute	Design options	Description
Number of rides permitted	Single	Valid for single-leg trip
	through ticket	Valid for multi-leg one-way trip
	Return	Valid for trip there and back
	fixed trip carnet	Valid for fixed number of defined trips
	stored value card	Valid for the number trips equivalent to the value on the card
	unlimited trips (period ticket)	Valid for any trip (on the stated service)
Duration of ticket	length of single trip(s)	Valid for a single trip
	Transfer	Valid for an end to end trip with includes a transfer within a limited amount of time
	day ticket	Valid for unlimited trips on a single day
	multi-day ticket	Valid for unlimited trips in a limited period, usually 3 or 5 days
	season ticket	Valid for unlimited travel for a set period of time, typically 1 week, 1 month, or 1 year
	unlimited period	A ticket with no time constraints, sometimes called 'open' ticket
Distance discrimination	flat fare	A single price for the fare
	zonal fare	Prices increase or decrease across geographical zones or physical boundaries
	staged fare	Prices which are discretely set according to destination or boundary; similar to zonal but usually along a single route
	mileage-based fare	Prices increase according to the distance travelled
Integration level	single operator/ single mode	Fare is linked to a single operator, single mode
	single operator/ multi-mode	Fare is linked to one operator for multiple modes
	multi-operator/ single mode	Fare is eligible for all providers using a single mode
	multi-operator/ multi-mode	Fare is eligible for all providers and all modes
	multi-service	Fare allows related services or provides benefits to user, some of which may be non-transport
Number of users	one person	Fare or ticket is valid for one person
	group tickets	Fare or ticket is valid for number listed on artefact
Ticket exclusivity	Transferable	Fare or ticket can be given to another user
	non-transferable	Fare or ticket is only valid for named user
Type of individual	non-differentiated	Same fare for all users
	Concessions	Fare changes based on user characteristics (e.g. student, disabled) or trip characteristic
Differentiation by time	valid anytime	Fare or ticket is valid at any time
	peak and off peak	Fares typically are higher during peak periods and off peak tend to have lower fares
	crude yield management	Fares which are adjusted, by bands, according to level of bookings, or potential demand, on a service
	real time yield management	Fares which are adjusted according to actual demand at the time of booking
Ancillaries	all in tickets (bundled)	Ticket or fare which includes all 'extras' bundled into a single price (also called bundled services, or package); usually only one class of ticket

Fare structuring domain: 9 attributes		
	ticket segmentation (packages)	Tickets or fare which are segmented according to services provided
	disaggregated service attributes	Tickets or fares which are highly unbundled and each service is paid for separately
Payment and Control Domain: 3 Attributes		
Timing of payment (POS)	in advance (pre-trip)	transaction occurs before the trip, usually pre-booked
	at the barrier	transaction takes place at gate or barrier
	boarding the vehicle	transaction takes place as user boards the vehicle
	on board the vehicle	transaction takes place on the vehicle
	exiting the vehicle	transaction take place as the user leaves the vehicle
	post trip payment	transaction takes place after journey is completed
Ticket medium	cash (exact fare)	Fare required is the exact amount in coin or paper notes
	cash (change given)	Fares can be paid in coin or note form and change is given
	tokens (weight)	Tokens must be purchased to use the system
	tokens (chip)	Token which contains a chip and must be purchased to use the system
	printed tickets (visual)	Printed ticket provided to gain access to system
	printed tickets (barcode)	Printed tickets with scannable codes which permit access (also includes QR-codes)
	ticket (magnetic strip)	Tickets with a magnetic strip usually
	contact smartcard (chip)	Dedicated plastic card with embedded chip is used to record all tickets and trips; funds can be pre-loaded or transferred electronically
	contactless smartcard (RFID)	Dedicated card with RFID which allows contactless ticketing; has similar functions as above
	contactless bank card (RFID)	A national issued bank card which uses RFID to pay for transactions and the transport system simply charges the account linked to that bank card.
	mobile phone	Payment is achieved through an application within the mobile phone using either QR code scans, or other means of electronic transfer
Control methods	open system control	There are no barriers or controls for users within the transport system.
	closed entry, open exit	A transport system which uses entry checks, such as gates, but allows barrier-free egress.
	open entry, closed exit	A transport system with no entry barriers but employs gates, barriers or checks during egress to ensure payment was completed.
	fully closed system	A transport system which requires users to log both the start and end of the journey typically using physical gates, or points of contact for tickets/devices.

3. Findings

The ticketing board reflects the huge array of different ticketing systems globally. Each system has evolved according to its own unique context and policy goals and typically created a bespoke solution. We demonstrate privately-operated systems in the UK seek to maximise revenues through multiple fare

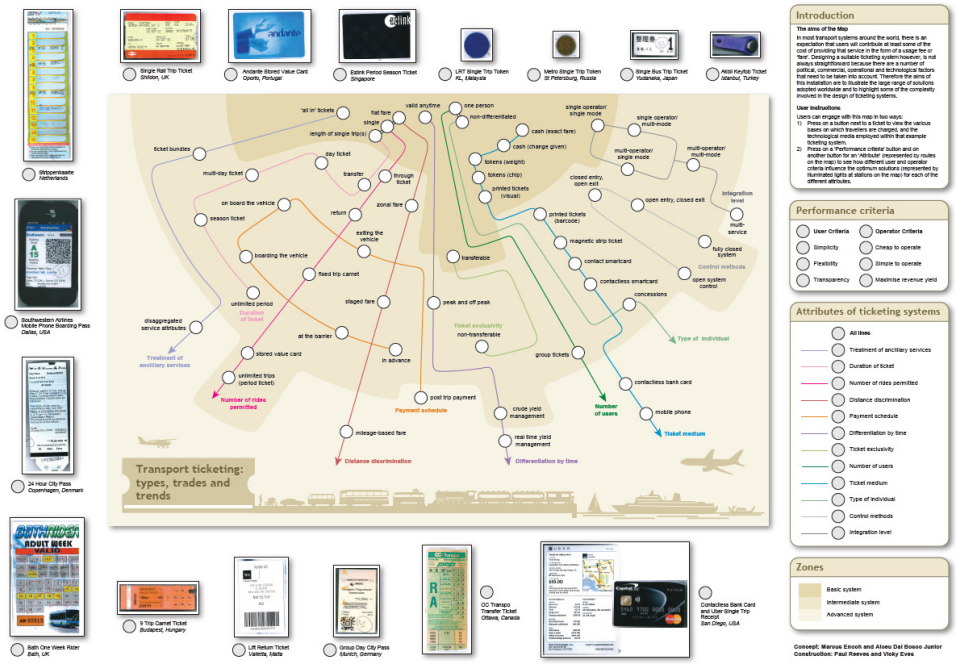

Figure 1. Tickets and attributes as graphically represented on the ticketing board

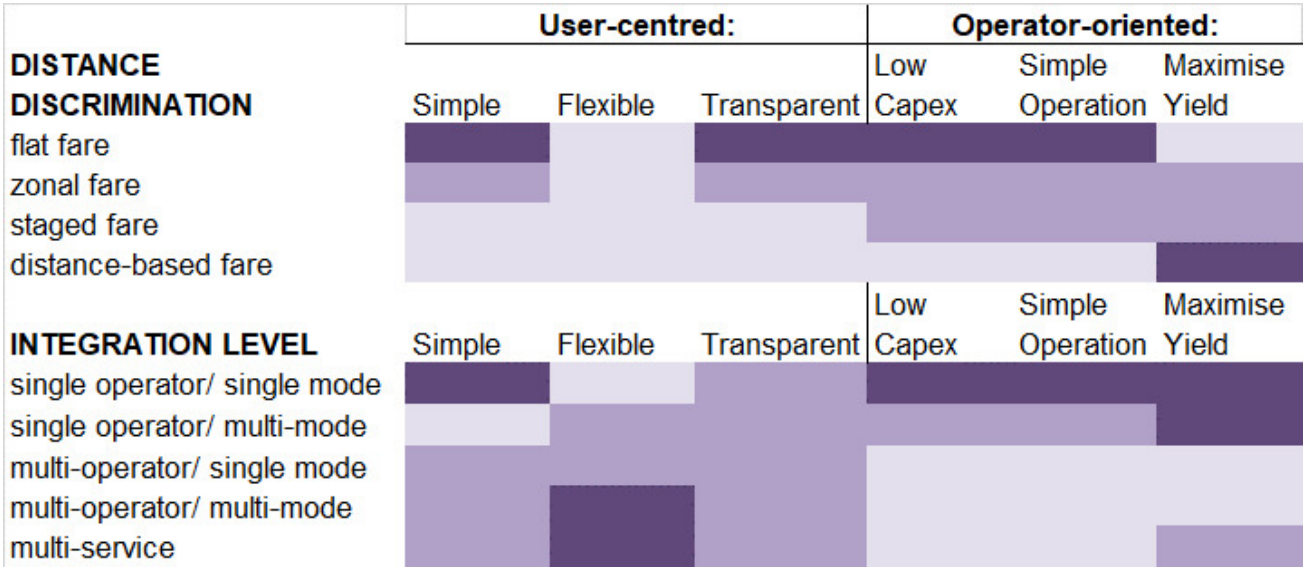

Figure 2. Example heatmap of ticket type attributes against performance criteria (darker colours indicate closer alignment against criteria).

differentiation strategies and strong enforcement regimes requiring high-tech equipment for collecting, monitoring and enforcing payment. In Europe, goals of encouraging users for public policy reasons and prioritising service efficiency mean much simpler fare structures and less ticketing infrastructure, but a higher need for subsidy. Differences are also shown between modes. City-based, short-distance mass transit modes such as metro systems where changing services and paying small amounts close to, or at the time of departure may

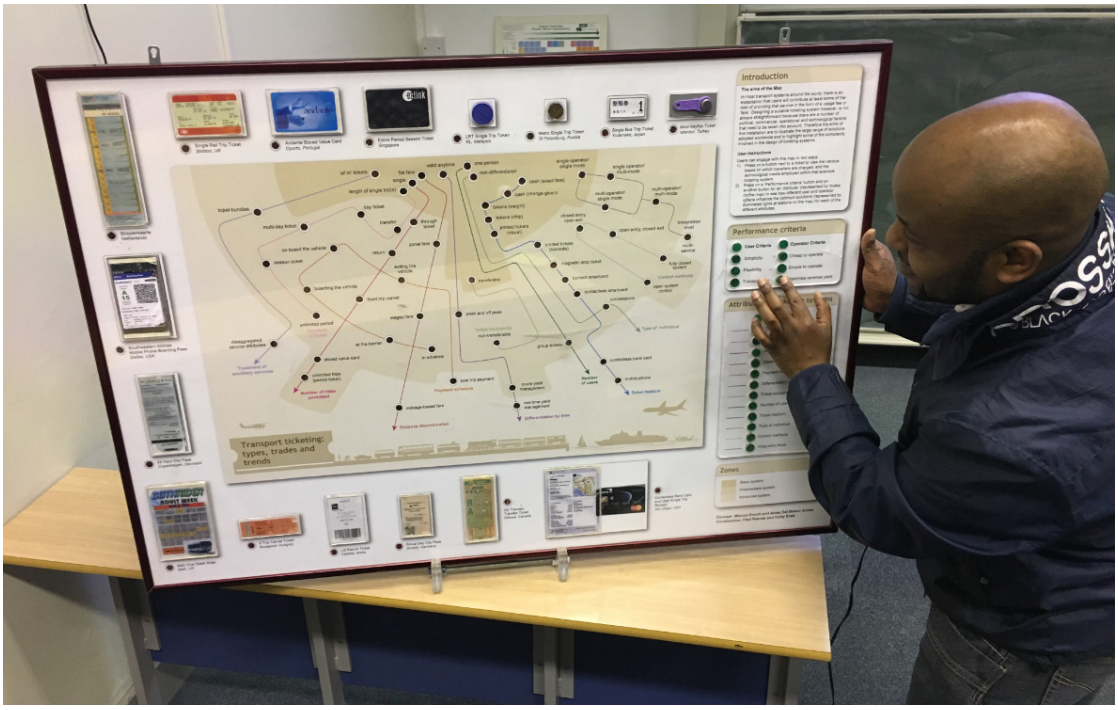

Figure 3. The ticketing board in the classroom

be features of use, use cash or smart card payments and a simple fare structure is adopted. By contrast, fares are often much more differentiated for longer distance and more occasional trips made on services like airlines or interurban rail.

The board exhibits recent technologies (e.g. smartphones, contactless payment) that are rapidly changing this landscape, and so promotes discussion of possible futures. Interestingly one group reported that new systems will see specialist suppliers delivering a 'one-size-fits-all' approach to pricing and ticketing, where the need to prioritise one policy objective at the expense of another may well be much reduced.

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SUPPLEMENTARY MATERIALS

Supplementary Materials 1

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Supplementary Materials 2

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